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PRICE ARBITRAGE BETWEEN QUEENSLAND CATTLE AUCTIONS

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In a competitive market with free information flows, spatial arbitrage will ensure that average prices at geographically separate markets will move in unison. The speed of adjustment is related to information flows between markets; if adjustment lags exist, there may be opportunities for arbitragers to gain. The transmission of price information is modelled using Johansen's procedure and the existence of long-run arbitrage opportunities is investigated. An innovation analysis is used to examine the varying responses to changes in prices at spatially separate markets.

Introduction

Slaughter cattle are traded at several different auction centres throughout Queensland. The existence of spatial markets for the same commodity arises primarily because of transportation costs and, to a lesser extent, communication costs. In a competitive market with free information flows, arbitrage will ensure that prices at spatially related markets move in unison, with price differentials reflecting only the costs of transfer between the different centres. Thus, a price change at one market will be followed by similar price changes in the other markets.

It is the speed with which prices adjust to changes in market forces, and specifically, to changes in the price of the same commodity at other markets, that is of prime concern in this paper. Whatever the market structure, oligopolistic, oligopsonistic or competitive, the speed of any price adjustment is related to the effectiveness of information flows between the markets. If adjustment lags exist, there may be opportunities for arbitragers to gain. Those most informed, and most flexible, in the case of slaughter cattle, are the buyers who operate throughout the State on a daily basis. It is to such buyers that any arbitrage opportunities may be open. Sellers, who may not have access to such immediate information or who may be subject to lags between

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the decision to sell and the actual sale, are less likely to gain from these arbitrage opportunities.

In this paper, price arbitrage between Queensland cattle auctions is modelled to determine how quickly price changes in one geographical sector of the market are diffused to other areas.[1] Faminow and Benson (1990) have shown that the existence of such price interdependence cannot be interpreted as indicating market efficiency or competition. Indeed, they illustrate that spatial price integration is consistent with basing-point pricing, rather than with the usual setting of competitive pricing. The concern in this paper is the existence, rather than the cause, of any price interrelationships. However, any arbitrage opportunities will be identified in the following analysis.

Price Arbitrage Mechanism

Prices reflect information about demand and supply not only at the market to which they are identified but also at other spatially related markets for that commodity. The transmission of this information between markets will affect the nature of the relationship between the prices at different markets. There are two related aspects to the transmission of price information: the first is the speed with which new price information is transmitted to and absorbed by other markets; and the second is the direction in which the prices adjust in relation to the information.

The speed with which price information is transmitted can be measured by examining the time taken for prices in spatially separate markets to adjust to a price change elsewhere. The speed of this adjustment can provide an indication of the integration of the markets, and may even aid in the definition of relevant market areas (see Ravallion (1986), Faminow and Benson (1990) and Sexton, Kling and Carman (1991)). As noted above, it will also indicate whether arbitrage opportunities are likely to exist between the markets and it is to this aspect of the transmission of price information that this paper is primarily focussed.

Garbade and Silber (1979) and, later, Koontz, Garcia and Hudson (1990) focussed their analysis of dominant-satellite markets on the second aspect of price transmission, the direction in which prices adjust. They examined the asymmetry apparent in information flows and, thus, in price movements. Where the price in one market persistently leads prices elsewhere, a lead-lag relationship exists between prices at this 'dominant' market and the spatially separate 'satellite' markets. Satellite markets may be responding less efficiently to evolving information, or alternatively, they may not be considered to be a source of significant new information about the broader market. The

[1] See Buccola (1980); Spreen and Shonkwiler (1981); Bessler and Brandt (1982); Marsh (1985); and Van Tassell and Bessler (1988), *inter alia*, for other studies in which the transmission of prices between different cattle types is considered.

dominant market(s), with its (their) usually greater volume of trade will provide the required market information. This second issue is investigated indirectly in the following analysis by examining the extent to which prices adjust to changes in different markets.

While Granger-causality tests could reasonably be utilised to test for the direction of information flows in studies based on average weekly or daily prices (see Garbade and Silber, and Koontz *et al.*), Queensland markets operate on different days of the week and temporal links would tend to dominate the causal links in standard causality tests.

The Modelling of the Price Transmission Mechanism

Following Sims (1980), a Vector Autoregressive (VAR) approach has been adopted to model the price transmission mechanism. Sims argues that possible misspecification bias from inappropriate economic theories can be replaced by the inefficiency of a dynamic reduced-form VAR system which is over-parameterised. Economic modelling using a VAR approach allows the data set to reveal the appropriate dynamic structure, which is generally not defined by economic theory. Providing that a reasonable sample size is available, the relative loss of efficiency in parameter estimates is likely to be more than outweighed by the lack of specification bias.

The modelling of the price transmission mechanism using a VAR approach has been used elsewhere; see, for example, Babula and Bessler (1990), Bessler (1984), Brorsen, Chavas, Grant and Ngenge (1985), Van Tassell and Bessler (1988), Bailey and Brorsen (1985), and Schroeder and Goodwin (1990). The general form of the model to be estimated for n individual price series is:

$$(1) \qquad Y_t = a + \sum_{i=1}^{p} A_i Y_{t-i} + V_t,$$

where Y_t is an n x 1 vector of the logarithms of the prices at time t; a is an n x 1 vector of parameters; A_i, $i = 1, ..., p$ are n x n matrices of parameters; V_t is an n x 1 vector of independently and normally distributed disturbances with $E(V_t V_t') = \Omega$, and p is the lag length.

Nonstationarity, or the absence of a constant mean and variance of a series over time, is a common feature of time series price data. Until recently, two techniques were used to make allowance for this problem in a VAR analysis. The first of these is to augment equation (1) with a time trend in the 'Minnesota' tradition established by Sims as in Bessler, and Van Tassell and Bessler. The second approach is to difference all of the time series to induce stationarity as in Bailey and Brorsen; Schroeder and Goodwin; and Faminow and Benson.

Neither approach is entirely satisfactory. Inclusion of a time trend may alleviate the nonstationarity problem if the series are trend-stationary but it is unreasonable to assume that, over a long time period, behaviour can be described by simplistic deterministic time trends. Importantly, such a set of equations would imply that prices must diverge in the long run unless the coefficients on the time variable in each equation were forced to be the same.

The problem with modelling dynamics by (1) with nonstationary price series is highlighted when innovation analysis is carried out. Impulse response functions, showing the responses of all the price series to a unit (one standard deviation) shock, or innovation, in one price series can be found to be unrealistically slow to dampen after a price change (see Bessler, and Schroeder and Goodwin). Phillips (1991) has indicated other statistical problems that exist with unrestricted VAR models which are formulated in levels.

On the other hand, first differencing all the data series removes too much information about any long-run relationships that might exist between the price series, and will bias the estimates of the coefficients (see Nerlove, Grether and Caravalho (1979) and Banerjee, Dolado, Hendry and Smith (1986)). The polarity of models in levels and those in first-differences can be highlighted by considering a reparameterisation of (1).

$$\Delta Y_t = a + \sum_{i=1}^{p-1} B_i \, \Delta Y_{t-i} + D \, Y_{t-1} + V_t \,, \tag{2}$$

where

$$D = [\sum_{i=1}^{p} A_i - I] \quad ; \quad B_i = -\sum_{j=i+1}^{p} A_j \tag{3}$$

and both the constant, a, and the disturbance vector, V_t, are as defined in (1).

If D is unrestricted, *i.e.* rank(D) = n, ordinary least squares estimates of the levels model (1) and equation (2) are directly related by (3). If $D = 0$, that is rank(D) = 0, the first-difference model is appropriate and, hence, equation (1) is over-parameterised and its estimates are inefficient. Between these two extremes are vector error correction models that have rank(D) = r, $0 < r < n$. In such cases, equation (1) is again over-parameterised but estimates of the parameters in equation (2), with $D = 0$, are biased owing to the implicit omitted variable problem. Johansen and Juselius (1990) have proposed tests to determine the rank of D, and Johansen (1988) has derived the maximum likelihood estimator for the case when $0 < r < n$.

The determination of the rank of D is equivalent to finding whether any cointegrating relationships exist between the prices at separate markets.[2] If $D = 0$, then no cointegrating relationships exist; if $n >$ rank(D) = $r > 0$, there are r cointegrating relationships.

[2] Cointegration exists when stationary linear combination(s) of nonstationary time series exist.

Cointegration of time series implies that long-run relationship(s) exist between the series and such long-run equilibria between prices at different markets indicate market integration (Ravallion, and Goodwin and Schroeder). Goodwin and Schroeder use pair-wise cointegration testing in this way to investigate price linkages between different markets.

In the following analysis, use is made of Johansen's system approach to establish the existence of stable long-run relationships between prices at separate markets. An appropriate vector error correction model, incorporating these relationships, is then developed to investigate the speed with which prices adjust in response to a one-time shock in the equilibrium relationships.

Data

An important segment of the Queensland slaughter cattle market is the heavy steer, or Jap-Ox, market. These cattle are almost exclusively exported to Japan. One advantage with using this type of cattle for the analysis is its relative homogeneity. The classification "Jap-Ox" is tightly defined, with cattle required to meet minimum weight, fat and muscle score requirements. Cattle meeting these requirements will attract the premium price associated with Jap-Ox, with little price variation associated with other characteristics.

This analysis has been limited to Jap-Ox because, for other categories of cattle, quality variations as indicated by different breed, area of origin, and weight and fat scores are wide between different regions of the State, with prices varying accordingly (Williams and Rolfe (1991)). This heterogeneity would unnecessarily confound the analysis of information flows.

The data used in this analysis are the average prices for Jap-Ox sold on each day and are derived from livestock market reports collected by the Livestock Market Reporting Service of the Livestock and Meat Authority of Queensland. Each market meets on a weekly basis so that effectively the data are weekly time series. The series used here are for four of the major saleyards in Queensland for the Jap-Ox market: Rockhampton, Toowoomba (2 saleyards with markets on different days) and Townsville. All three centres are located in the main cattle producing areas of Queensland with Townsville in the north and Toowoomba in the south; whilst Rockhampton is located approximately halfway between the other two centres and is dominant in terms of saleyard volumes. The period covered by the analysis is March 1986 to August 1989 leaving 169 observations for estimation after lags have been taken into account.[3]

[3] The presence of Christmas, Easter and other public holidays, the breakdown of electronic data collection devices and adverse weather can each cause the cancellation of an auction or the omission of the record of an auction which did take place. In such cases, missing data were replaced by the average of the adjacent prices. It should also

cont. ...

The four price series, measured in cents per kilo liveweight, are presented in Figure 1. The logarithm of the ratio of each price series to that for Rockhampton is shown in Figures 2 to 4 and the change in the log-price for Rockhampton in Figure 5. Casual empiricism suggests that the individual price series are nonstationary and the fact that the log-price ratio series are less trending than the raw data suggests that there might be a single common time trend to all prices. These assertions are tested with augmented Dickey-Fuller (1979) tests, where the log-average prices are defined by

y_1 = Monday meeting of Rockhampton saleyard,
y_2 = Tuesday meeting of Toowoomba saleyard,
y_3 = Wednesday meeting of Toowoomba saleyard,
y_4 = Wednesday meeting of Townsville saleyard.

Third-order autoregressive processes were estimated for each series, the order being determined through a sequence of t-tests commencing with a lag length of 8. In the second column of Table 1, augmented Dickey-Fuller statistics are reported for the null hypothesis of nonstationarity against an alternative of stationarity; that is, an alternative of a process integrated of order zero, I(0) in Granger's (1981) notation. In the third column, corresponding statistics are reported for similar tests on the first-differenced series so that the alternative hypothesis in each case is that the time series is I(1), that is the first-difference of each time series is stationary. Thus, a rejection of the null in column 3, following a failure to reject the null in column 2, leads to a conclusion that a given series is I(1). The appropriate one-sided 5 per cent and 2.5 per cent critical values of the augmented Dickey-Fuller tests are –2.88 and –3.14, respectively (Fuller, 1976, p. 373).

TABLE 1
Augmented Dickey-Fuller Tests for Nonstationarity

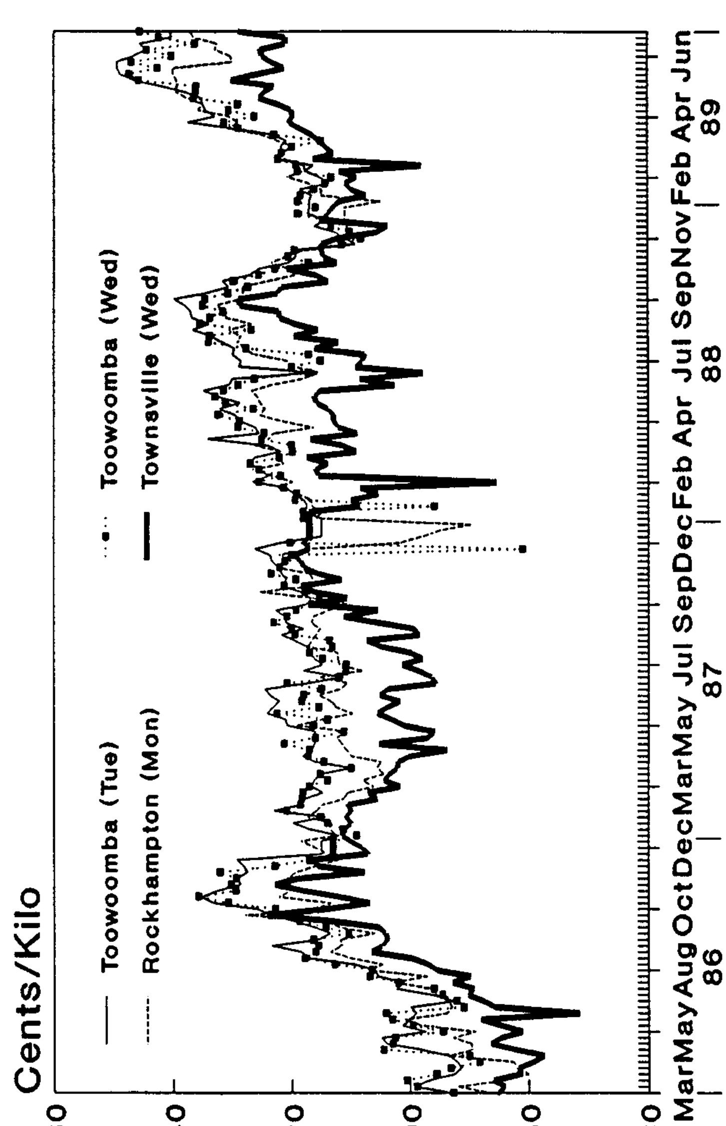
	Time series in:	
Variable	levels	differences
y_1	–2.68	–10.73
y_2	–2.48	–10.15
y_3	–2.65	–12.48
y_4	–2.94	–13.49
$y_2 - y_1$	–5.20	–13.01
$y_3 - y_1$	–6.88	–12.86
$y_4 -_1$	–4.48	–13.69

... *cont.*

be noted that the following analysis is quite robust to the deletion of observations 90-99 (December 1988 - February 1989) which are characterised be excess price volatility.

FIGURE 1

Weekly Average Prices of "Jap-Ox" Heavy Steers at Major Queensland Saleyards



Source: Livestock Market Reporting Service of the Livestock and Meat Authority of Queensland.

FIGURE 2
Log Relative Price: Toowoomba (Tue) to Rockhampton

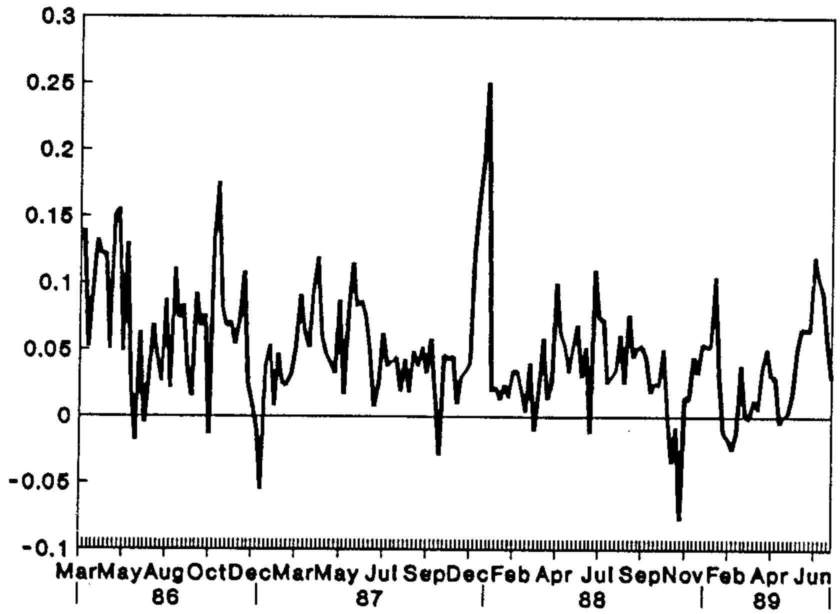


FIGURE 3
Log Relative Price: Toowoomba (Wed) to Rockhampton

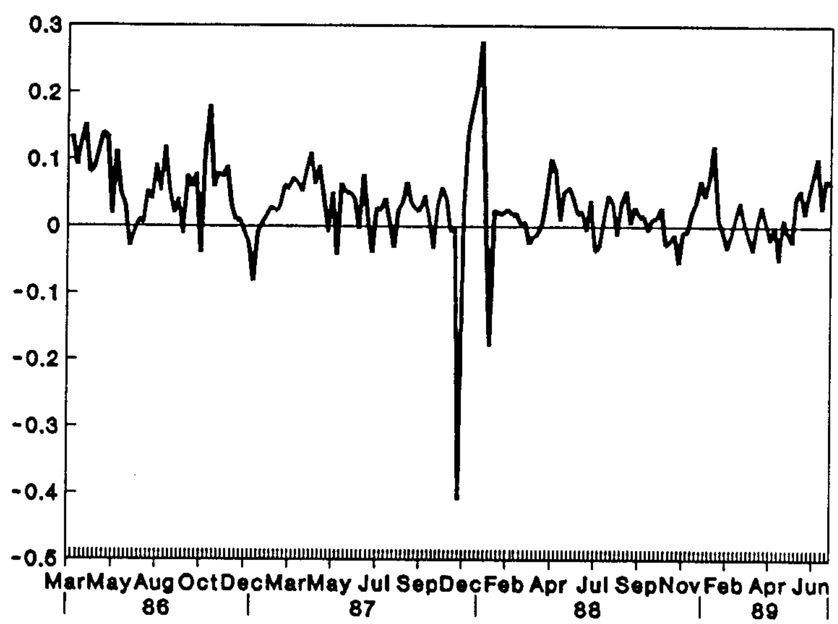


FIGURE 4
Log Relative Price: Townsville to Rockhampton

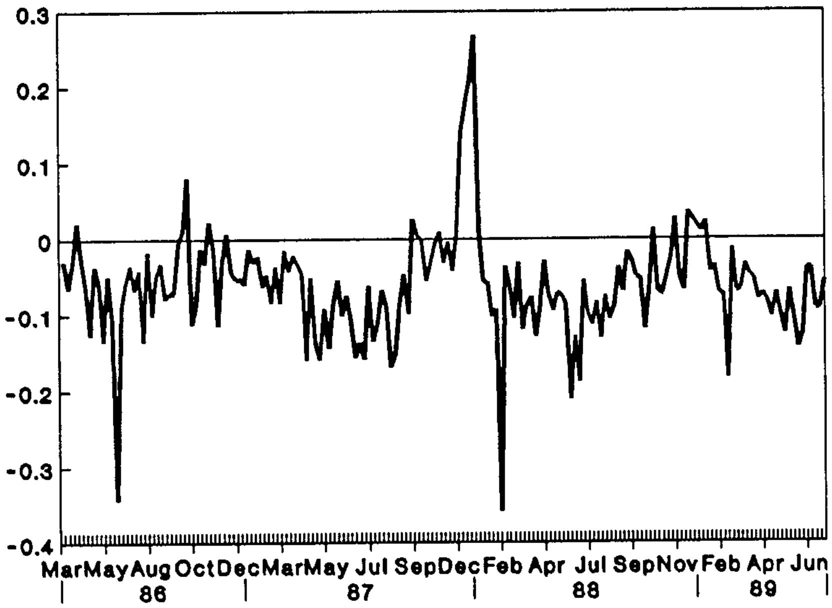
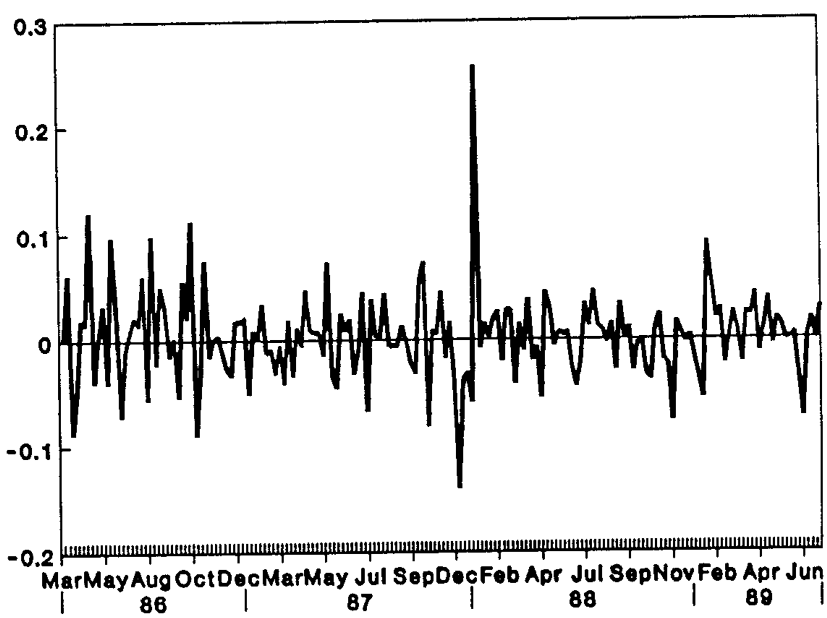


FIGURE 5
Log Change Price: Rockhampton



It follows from Table 1, therefore, that each of the three log-price differentials $(y_2 - y_1)$, $(y_3 - y_1)$ and $(y_4 - y_1)$ are I(0), and each of y_1, y_2, and y_3 are I(1), with each statement being made at the 5 per cent level of significance. It can be noted that y_4 is I(0) at the 5 per cent level of significance but, at the 2.5 per cent level, it can also be concluded that y_4 is I(1).

The Model

Whenever a set of time series are I(1), it is useful to consider whether the individual times series tend to move together in the long run. While Engle and Granger (1987) proposed a simple procedure for detecting this phenomenon, known as cointegration, the extension to the multivariate case is somewhat more complicated.

Johansen (1988) proposed a maximum likelihood estimation procedure for jointly estimating the parameters of any cointegrating relationships and the dynamic structure within the framework of equation (2). Johansen's procedure in the current context involves the transformation of the four log-price series into four linear combinations in a canonical analysis of the original series. If r long-run (cointegrating) relationships exist, r of the linear combinations (canonical variates) are stationary and $n-r$ are nonstationary. The imposition of cointegration on (2) can be expressed as rank restrictions on the matrix D. Johansen and Juselius' (1990) maximal eigenvalue and trace statistics are used to determine r and these statistics, together with 95 per cent critical values, are given in Table 2.

TABLE 2
Johansen and Juselius' Tests for Cointegration

	Maximal eigenvalue		Trace statistic	
Null hypothesis	observed value	95 per cent critical value	observed value	95 per cent critical value
$r \leq 3$	4.77	8.18	4.77	8.18
$r \leq 2$	23.47	14.90	28.23	17.95
$r \leq 1$	33.94	21.07	62.17	31.52
$r = 0$	76.97	27.14	139.14	48.28

Given that both test criteria in Table 2 indicate that the null hypothesis $r \leq 2$ should be rejected at the 95 per cent level, but that the null $r \leq 3$ should not be rejected, it is concluded that there are three cointegrating equations, or stable long-run relationships, linking the four series with only one $(n-r)$ source of nonstationarity. The three stationary canonical variates, z_i, $i = 1, \ldots, 3$ can be expressed as

$$
\begin{aligned}
z_1 &= 0.5744\, y_1 + 29.8331\, y_2 - 30.0602\, y_3 - 1.2033\, y_4 \\
z_2 &= 26.7245\, y_1 - 24.3728\, y_2 + 1.6245\, y_3 - 5.3800\, y_4 \\
z_3 &= 2.1830\, y_1 - 16.0628\, y_2 - 2.7257\, y_3 + 17.1898\, y_4
\end{aligned} \tag{4}
$$

or, equivalently, as $Z_t = M'Y_t$ where $Z_t = [z_{1t}, z_{2t}, z_{3t}]'$ and the 4 x 3 matrix M is implicitly defined by equation (4).

There is a clear pattern in the weights of these stationary linear combinations. In each case there is a dominant pair of relatively large coefficients with approximately equal and opposite signs. In turn, this implies that log-price differentials are important in defining the cointegrating basis.

The implicit restrictions on D in equation (2) that flow from three cointegrating relationships can be expressed as

$$
\Delta Y_t = a + \sum_{i=1}^{p-1} B_i \Delta Y_{t-i} + G\tilde{Z}_{t-1} + v_t \tag{5}
$$

where $\tilde{Z}_t = [\tilde{z}_{1t}, \tilde{z}_{2t}, \tilde{z}_{3t}]'$ is the 3 x 1 vector of error-correction terms derived from Z_t by subtracting the mean of each linear combination, z_{it}, over t from z_{it}, and G is a 4 x 3 matrix of parameters implicitly defined by $D = GM'$.

OLS estimation of equation (5), conditional upon the maximum likelihood estimates of the weights used to form the canonical variates in equation (4), produces parameter estimates which are numerically identical to the maximum likelihood estimates defined in Johansen; these estimates are presented in Table 3. It can be noted from that Table that each error-correction term is significant at the 5 per cent level in at least one equation and each equation has at least one significant error-correction term.[4] Joint tests of significance suggest that the deletion of any one of these error-correction terms from the system as a whole would be rejected at even the 0.1 per cent level of significance.

It is also clear from Table 3 that $\Delta y_{4,t-1}$ is highly significant in the $\Delta y_{4,t}$ equation while all other lagged changes, both in that equation and the other three, are insignificant at the 5 per cent level. The joint null hypothesis that $B_i = 0$ in equation (5) is rejected using Sims adjusted likelihood ratio test since the observed value of this statistic is 29.52 which can be compared with a 95 per cent critical value of $\chi^2(16) = 26.3$.

The importance of detecting the lagged effect in the Townsville equation is that this geographically isolated saleyard is the only one of the four that significantly reacts directly to its own past changes. The other three prices are more sensitive to the differentials in the market place; that is, the degree to which markets are out of line with each

[4] An appropriate asymptotic normal 't-test' is applied in each case.

other. It follows that the Townsville market is less integrated with the other saleyards. Prices at Townsville appear to be determined more by local influences, including previous market conditions for Jap-Ox at this market. This behaviour suggests that Townsville can be considered a satellite to the major sales at Rockhampton and Toowoomba.

TABLE 3
Vector Error Correction Model

	Dependent Variable			
Regressors	Δy_{1t}	Δy_{2t}	Δy_{3t}	Δy_{4t}
$\Delta y_{1,t-1}$	–0.066	0.020	–0.105	–0.206
	(0.82)	(0.30)	(0.98)	(1.89)
$\Delta y_{2,t-1}$	0.128	0.001	–0.086	0.113
	(1.16)	(0.01)	(0.58)	(0.75)
$\Delta y_{3,t-1}$	–0.143	–0.072	0.010	–0.036
	(2.18)	(1.32)	(0.11)	(0.40)
$\Delta y_{4,t-1}$	0.074	–0.000	–0.004	–0.275
	(1.30)	(0.00)	(0.08)	(3.56)
$\tilde{z}_{1,t-1}$	–0.007	–0.008	0.255	–0.001
	(2.56)	(3.36)	(6.59)	(0.30)
$\tilde{z}_{2,t-1}$	–0.012	0.006	0.003	0.007
	(4.19)	(2.31)	(0.79)	(1.85)
$\tilde{z}_{3,t-1}$	0.000	0.003	0.004	–0.016
	(0.02)	(1.45)	(1.17)	(4.08)
Constant	0.002	0.002	0.002	0.004
	(0.85)	(0.95)	(0.59)	(1.00)

Asymptotic t-ratios are given in parentheses.

The equilibrium solution for the vector error correction model (5) can be obtained by solving $\tilde{Z}_{t-1} = 0$ which, from equation (4) can be expressed as

$$y_2 = 0.9567\,y_1 + 0.2521$$

(6) $$y_3 = 0.9320\,y_1 + 0.3521$$

$$y_4 = 0.9147\,y_1 + 0.3421$$

where the constants in (6) are the sample means of $(y_i - 0.9567y_1)$, $(y_i - 0.9320y_1)$ and $(y_i - 0.9147y_1)$.

Perfect spatial integration of markets requires that the coefficient on the long-run relationship between prices at these markets be unity (Goodwin and Schroeder 1991, p. 454). In the context of the current analysis, the existence of price integration, as revealed by unit coefficients on y_1, would allow the model to be correctly respecified in terms of the log-price differentials. Following Bewley and Theil (1987), the small sample distribution of this test is approximated in a Monte Carlo framework.

It follows from the relationship between (4) and (6) that equation (5) could have been specified with error correction terms $y_i - \beta_i y_1 - \alpha_i$, $i = 2,3,4$, without loss of generality. Thus, consider an alternative hypothesis corresponding to (6), which can be written as $y_i = \beta_i y_1 + \alpha_i$, $i = 2,3,4$, and a null hypothesis that the log-price differentials define the error correction terms in equation (5): $y_i = y_1 + \alpha_i, i = 2,3,4$. A statistic for the joint test that all of the β_i are unity is defined by

$$\hat{\beta} = \sum_{i=1}^{3} \mid 1 - \hat{\beta}_i \mid = 0.1966 .$$

The principle underlying Monte Carlo testing is to generate a large number of replications under the null hypothesis and compute a similar test statistic. The position of the observed test statistic $(\hat{\beta})$ in the empirical distribution provides a test of the null hypothesis. If the observed test statistic is, say, in the 5 per cent tail of the distribution, the null hypothesis is rejected. Accordingly, 4,999 replications of the vector error correction model (5), modified with log-price differentials replacing the error correction terms $(\tilde{Z}_t)$, are generated and, on each replication, a new estimate of β is computed. The observed $\hat{\beta}$ constitutes the 5,000th replication in this empirical distribution. The 5,000 estimates are then ranked in ascending order and the position of $\hat{\beta}$ located in this empirical distribution. This position emerged to be the 3,396th out of the 5,000. The 5 per cent tail does not include this value and so the null hypothesis, that the log-price differentials form a basis for the cointegrating vectors, is not rejected.[5]

Impulse Response Functions

Sims has argued that the dynamics of the relationship between a number of time series can be studied in an innovation analysis.[6] An innovation analysis simulates the effect of a one-time shock, or

[5] That is, the observed ranking would have to be less than or equal to 125, or greater than 4,875 to cause a rejection of the null hypothesis.

[6] See Phillips and Bewley (1991) for a recent application of innovation analysis.

innovation, in all of the series and on the other series in the system. The simulated paths traced by the series, or impulse response functions, are found by imposing a recursive structure on the moving average representation of the VAR model. It should be noted that this method is dependent on the order of the equations.

The problem of choosing an appropriate order for this innovation analysis must be resolved on *a priori* grounds (Bessler, 1984, p. 116). For this study, the four auctions occur on three separate days hence removing much of the ordering problem. The only duplication of market days occurs on Wednesdays with sales at Toowoomba and Townsville. Since there is a Tuesday sale at Toowoomba, it is reasonable to assume that price information would be transmitted to the Wednesday Toowoomba sale not later than the Townsville sale. The innovation analysis uses the order, Rockhampton, Toowoomba (Tuesday), Toowoomba (Wednesday), and Townsville.

The impulse response functions are presented Figures 6, 7, 8, and 9. Since each time series is expressed in logarithms, the vertical axes can be interpreted as approximate percentage changes. Thus, in the case of Figure 6, a one standard deviation shock of 3.6 per cent in the Rockhampton price has an effect of increasing the other three prices in the same week by between 0.5 per cent and 1.1 per cent. The responses in all four prices approach approximately 1.5 per cent in the long run. Interestingly, the price in Townsville does not rise sharply until the sale held more than two weeks after the original shock occured in Rockhampton. It can be noted from Figure 7 that the effect of a shock in the Toowoomba price on a Tuesday has no impact on the Rockhampton price in the same week since that market is held the day before. However, the Toowoomba (Wed) price quickly approaches that for the Toowoomba (Tuesday) sale. From Figure 8, it can be noted that the Toowoomba (Tuesday) price reacts more slowly to a shock in the price in the Toowoomba (Wednesday) price than the transmission in the reverse direction. Finally, from Figure 9, there is a relatively muted reaction to a shock in the price at Townsville. Indeed a large price differential emerges and takes up to eight weeks to dissipate. However, all four prices eventually approach similar equilibria.

Because the impulse response functions have been generated from a cointegrated system, there is a permanent effect to a shock in any one price and the long-run responses satisfy the cointegrating equations (4). In order to highlight the impact of shocks on price differentials, a second specification has been considered.

As an alternative to the standard vector error correction model (5), the three error-correction time series $\tilde{z}_{it}$ (i = 1,2,3) and the first-difference of one of the original series, say Δy_{1t}, can be modelled directly in an unrestricted VAR (Bewley and Parry (1991)). Given the results of the Monte Carlo testing procedure, log-price differentials can be used in place of the estimated error-correction terms.

FIGURE 6
Effect of an Innovation in the Rockhampton Price

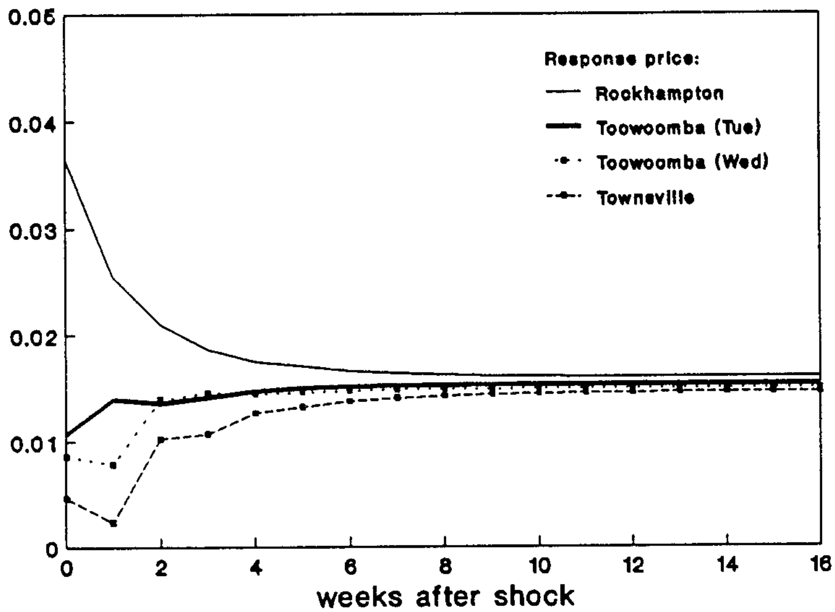


FIGURE 7
Effect of an Innovation in the Toowoomba (Tue) Price

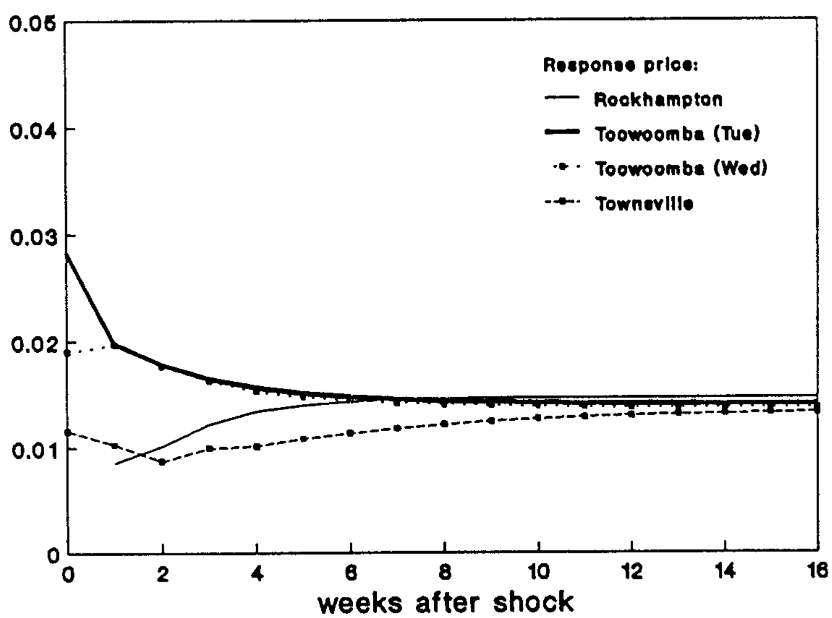


FIGURE 8
Effect of an Innovation in the Toowoomba (Wed) Price

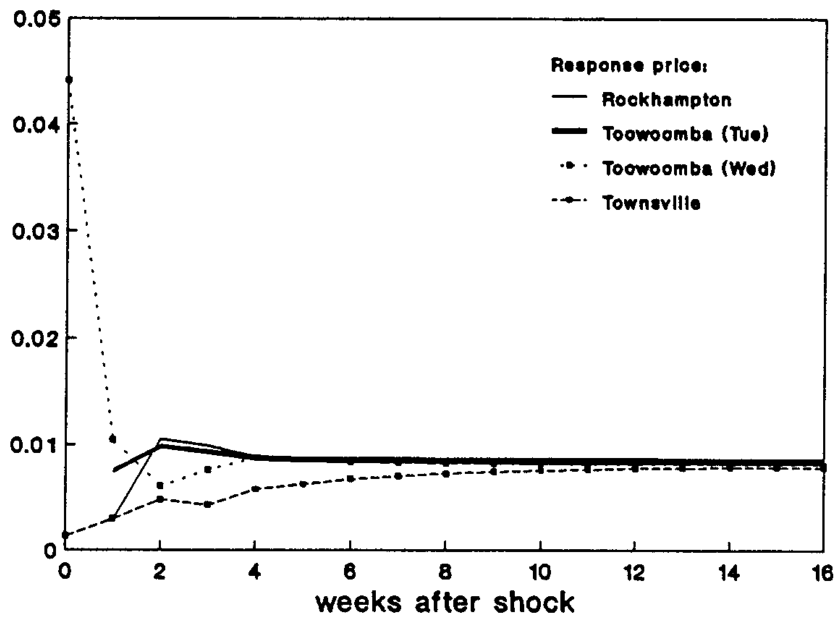
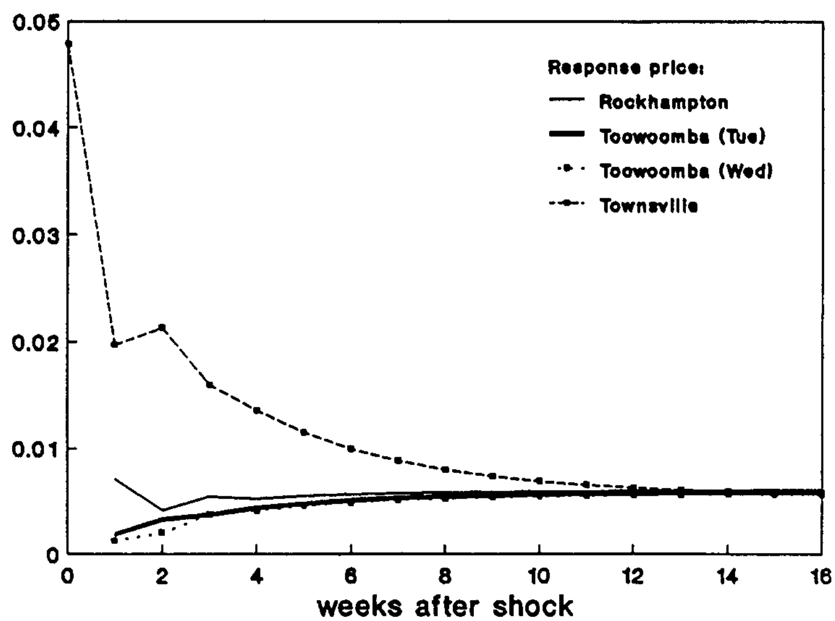


FIGURE 9
Effect of an Innovation in the Townsville Price



The first variable in the sequence is thus the change in the log of the Rockhampton price followed by the three log-price differentials in the order given. The impulse response functions, together with 95 per cent confidence intervals, are presented in Figures 10 to 13. The effect of the shock on the change in price at Rockhampton is shown in Figure 10 to have a negative impact on all price differentials. That is, the other prices absorb some of the impact. The adjustment of prices elsewhere to restore the differentials to some equilibrium level is shown to take a number of weeks. In Figures 11, 12 and 13, the impulse response paths map out the response of prices to a change in price in Toowoomba (both days) and Townsville. Given that Rockhampton, which provides the base price in the differentials, is chronologically prior to the other sales, impact changes in the differentials in week 0 cannot be due to changes in the base.

The impact of a unit (one standard deviation) shock in the log change in the Rockhampton price and in the Toowoomba (Tuesday) log price differential are seen to have a greater and more widespread effect on price differentials than a unit shock to the other two saleyards' price differentials. Indeed, it is suggested in Figures 12 and 13 that a unit change in each of the Toowoomba (Wednesday) and Townsville price differentials predominantly affects only the adjustment paths of the impacted variables. The Townsville-Rockhampton differential is, in all cases, slowest to adjust to a unit shock.

Townsville, and to a lesser extent Toowoomba (Wednesday), appear to be less dominant in the price transmission process. The response of other prices to changes in the prices at these centres is generally more muted. Price movements at Rockhampton, the first major sale of the week, appear to be dominant in their effect on prices elsewhere.

Following these conclusions, it is interesting to note the speed with which disequilibria in differentials, and new price information by way of a change in Rockhampton prices, are transmitted throughout the system. By far the greater proportion of a response occurs within 1-2 weeks with the exception of Townsville which takes an additional 1-2 weeks, possibly due to the time taken to get Jap-Ox to the saleyards after a price signal is recognised.

Conclusions

In the short-run, deviations from the equilibrium price differentials can be expected to close so that there may be opportunities to exploit disequilibria in the system. From the innovation diagrams in Figures 6-13 it can be noted that these opportunities are generally short-lived and the transactions costs associated with attempting to profit from forecasting prices might outweigh the potential gains. Arbitrage opportunities appear to be greater at Townsville but these may be offset by the costs of transport and cattle losses *inter alia* which could be incurred in the transport of cattle from Townsville to the other main sales centres.

FIGURE 10

Effect of an Innovation in the Change in the Rockhampton Price on :-

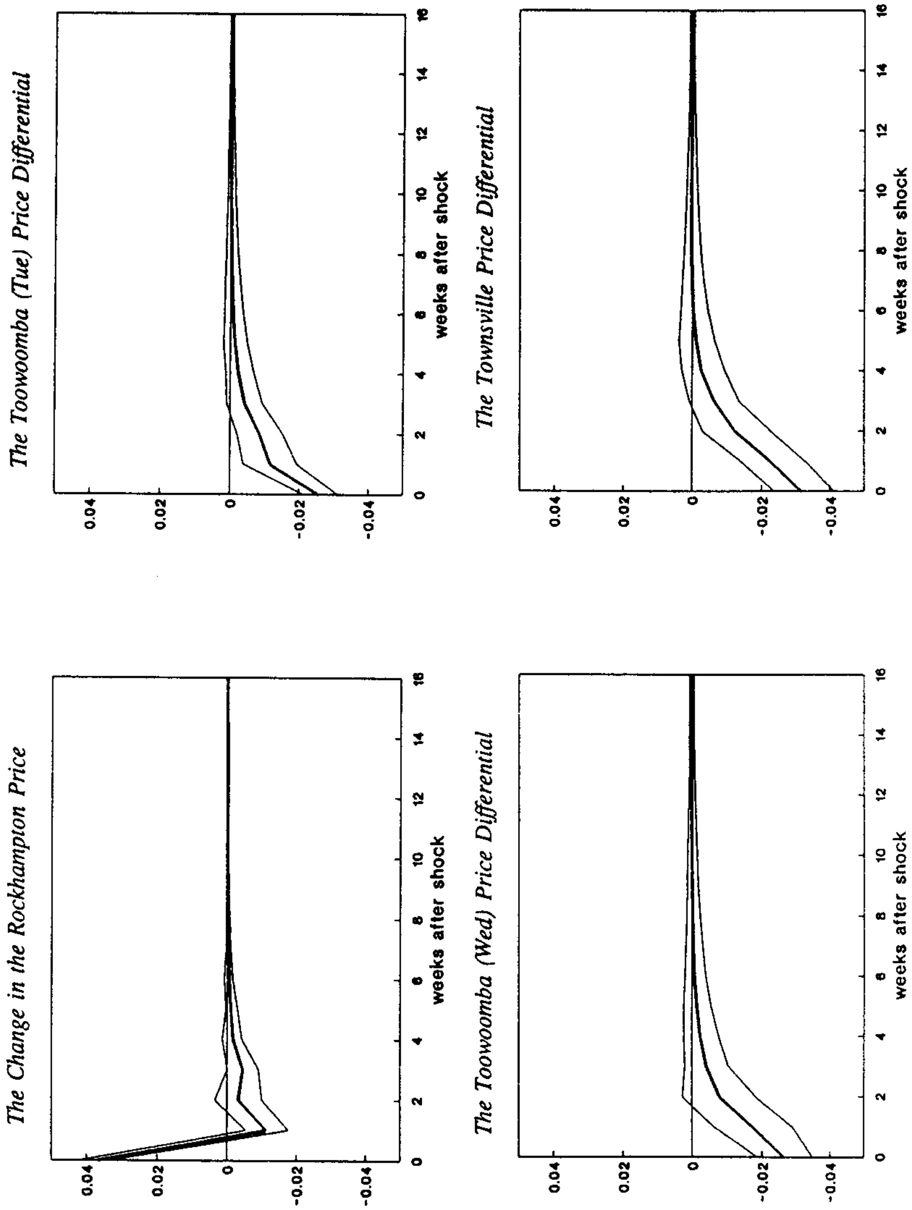
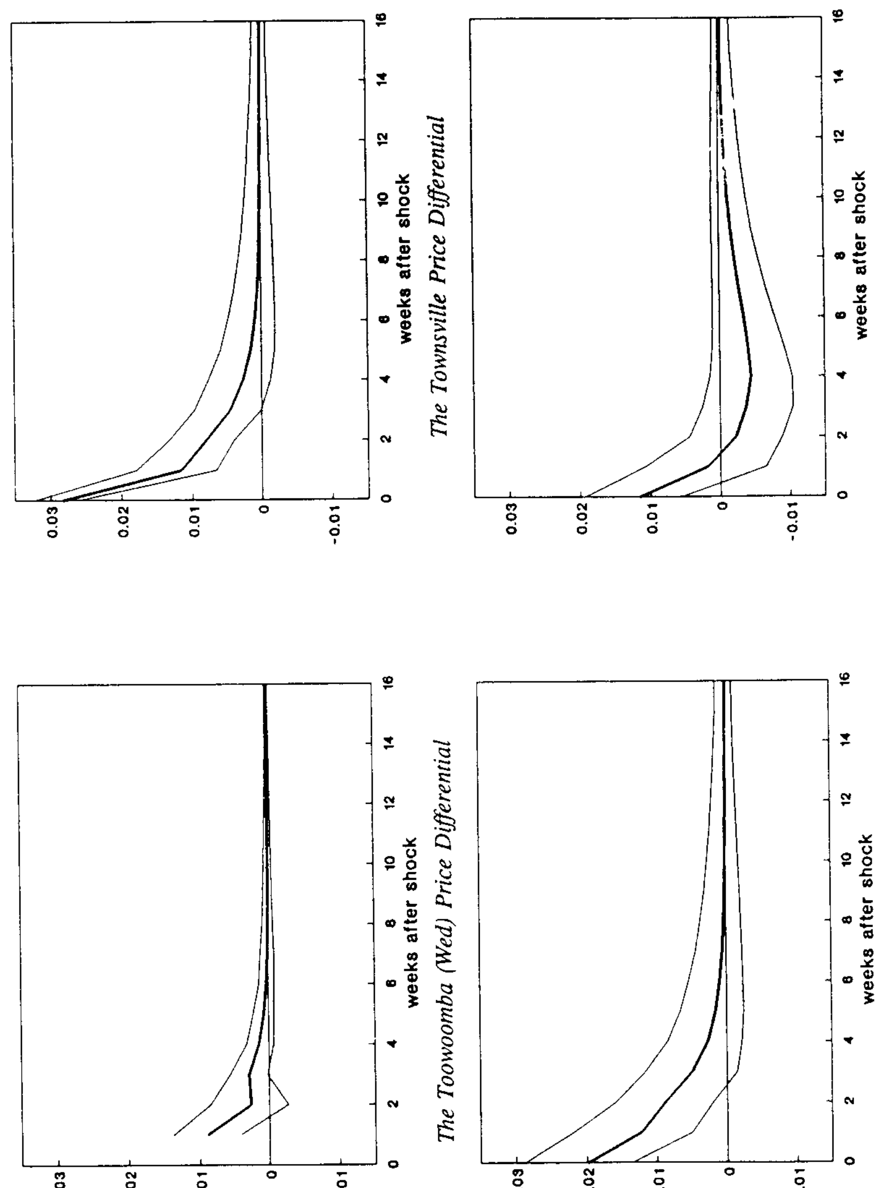


FIGURE 11

Effect of an Innovation in the Toowoomba (Tue) Price Differential on :-



The Change in the Rockhampton Price

The Toowoomba (Tue) Price Differential

The Toowoomba (Wed) Price Differential

The Townsville Price Differential

FIGURE 12

Effect of an Innovation in the Toowoomba (Wed) Price Differential on :-

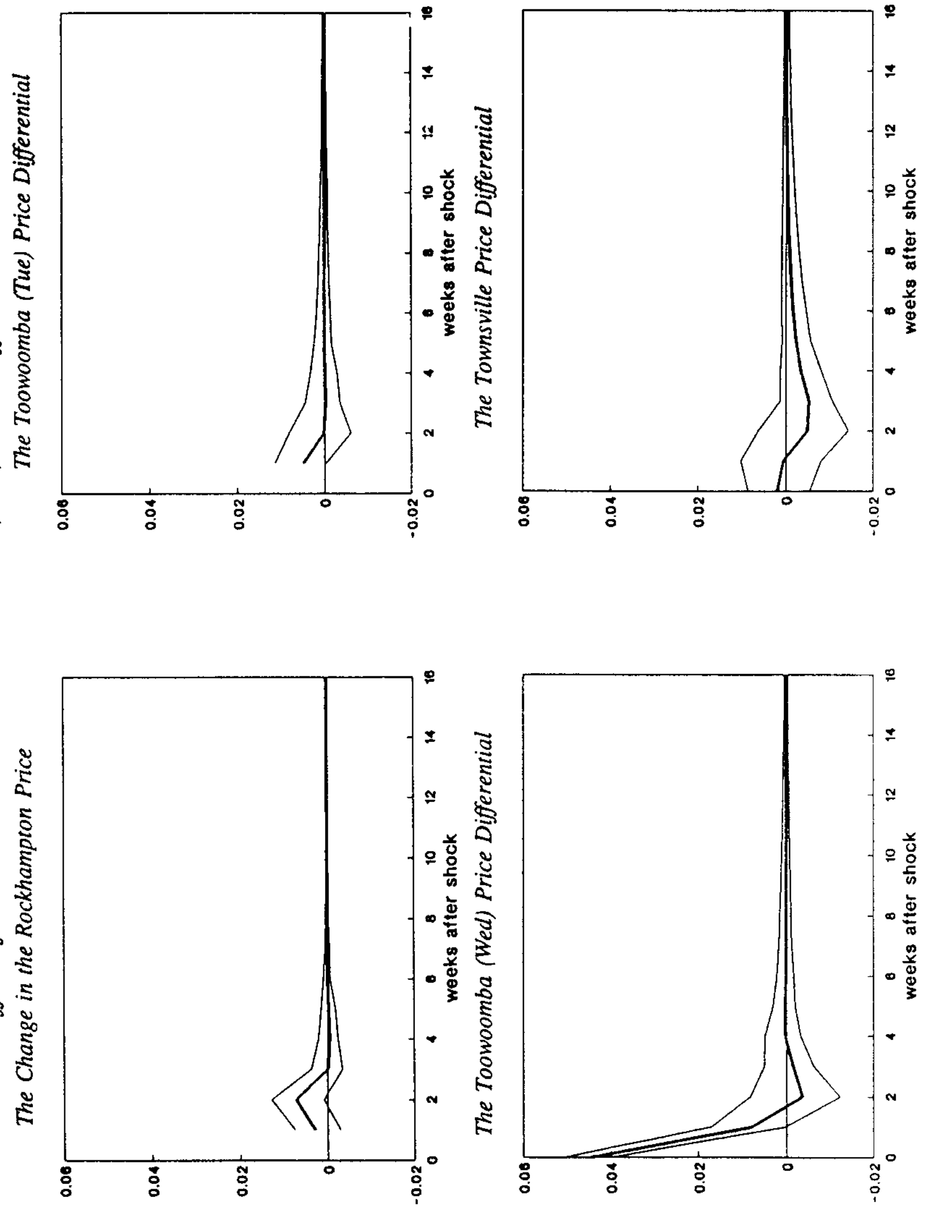
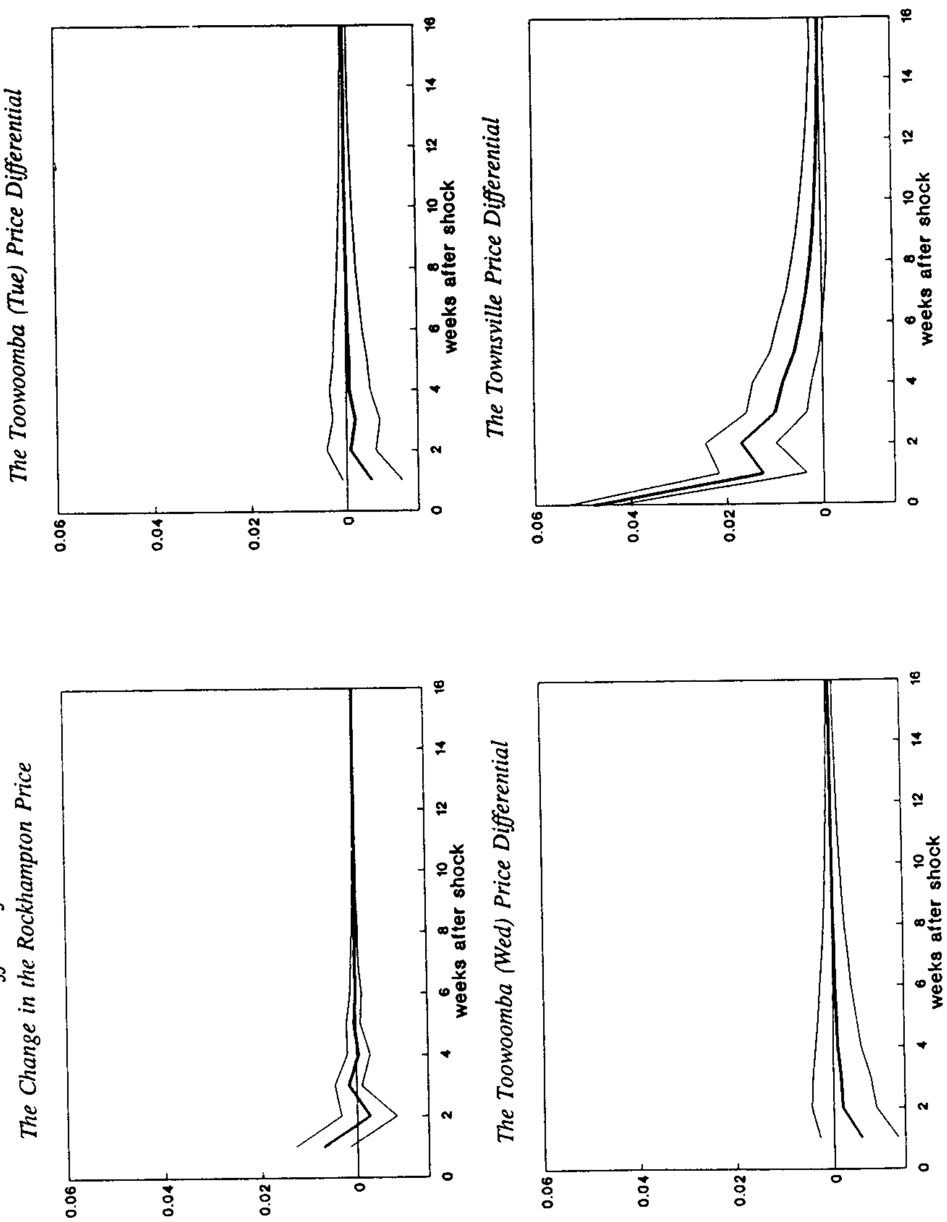


FIGURE 13

Effect of an Innovation in the Townsville Price Differential on :-



Townsville stands apart from the other three centres, with its previous market conditions playing an important part in the price determination process. This indicates that its degree of integration with the major markets of Rockhampton and Toowoomba may not be strong. Its smaller size and distance from the other centres may cause a less efficient use of the price information available in the market. In terms of the Garbade and Silber analysis, Townsville appears to have the characteristics of a satellite market.

The extent of price integration between spatially separated saleyards can be used in defining the geographic boundaries of a market. This problem of market definition is central to the anti-trust activities of the Trade Practices Commission in Australia and, indeed, one case recently brought by the Commission dealt specifically with the definition of any separate markets that may exist for fat cattle within Queensland.[7] As it was then, Section 50 of the Trade Practices Act (1974) focussed on the concept of 'dominance in a market' and the Court found that Northern Queensland, defined by Mackay and places to its north, constituted a separate market.[8] Accordingly, Australian Meat Holdings was required to divest itself of recent acquisitions in Mackay and in Bowen, a town approximately half-way between Mackay and Townsville. A study that included all of the relevant saleyards would be necessary to validate the Court's findings but the results presented here caution against such a sharp distinction between regional areas being made and suggest that the strength of price integration may be a declining (continuous) function of distance from the dominant centre.

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[7] Trade Practices Commission v. Australian Meat Holdings (TPC, 1988).

[8] Mackay is approximately halfway between Rockhampton and Townsville.

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